THE OMENTUM AND ITS FUNCTIONS.

BY GORDON K. DICKINSON, M.D.,
OF JERSEY CITY, N. J.
Late Surgeon, City Hospital; Surgeon, Christ Hospital; Consulting Surgeon, Bayonne Hospital.

THE concept of the omentum in the minds of most of our writers has been incompletely stated, the anatomist having the most to say in his descriptions of its various folds. Until recent years but few accurate observers have endeavored to describe its structure or numerous functions. A detailed study of this tissue brings to light many researches which give evidence of its great importance in the protection of the peritoneal cavity. It is impossible to discuss this organ apart from the conditions of the general peritoneal surface; nevertheless, owing to its histo-anatomy being somewhat distinctive, its functions are, to a certain extent, unique.

Embryology.—By the end of the first month of fetal life the digestive tract is formed, consisting of but a single tube; a dilatation in the upper part of which becomes the future stomach. This dilated portion is situated in the future thoracic cavity; has two attachments, known respectively as the anterior and posterior mesogastros; the posterior curvature becoming more pronounced than the anterior. Just below the stomach, in the third week, a rudimentary liver evaginates into the anterior mesogastrium, and in the fourth week, the pancreas into the posterior. The position of the pancreas and its early attachments to the mesial line determines the fixation of the duodenum, which is the first part of the intestinal tract to become fixed. In the meantime, the stomach descends toward its future normal position, rotating at the same time, so that what was the posterior border becomes the inferior, and the anterior, the superior. The posterior mesogastrium becomes redundant, out of proportion to the requirements of its visceral connections, and, to some extent, independent of the direct mechanical purpose of carrying blood-vessels to the viscera.[6]

The growth of the spleen carries the attachment of this membrane to the left. The posterior, or right surface of the mesogastrium, forms the cavity which is known as the cavity of the lesser omentum.

At, or soon after, birth there is a cohesion of the posterior layer of the omental fold with the transverse mesocolon. By this cohesion the pancreas becomes covered and the buried peritoneal surfaces absorbed, areolar tissue taking its place. Through this, the transverse colon seemingly becomes a part of the descending layer of the omentum.

Anatomy.—Another entirely different view of the omentum is obtained from the study of general anatomy. From time immemorial, and practically without any alteration in detail, anatomists have contented themselves with a description of the omentum as being "a complicated folding of the peritoneal surfaces," submitting careful descriptions of the several layers with their origin.

The omentum is a reticulation of connective tissue, carrying a double fold of peritoneal membrane, extending from its parietal attachment on the posterior abdominal wall, down more or less deeply into the abdomen, then up to become attached to the lower portion of the stomach and gastro-splenic ligament. The retrogastric space, which includes the space between the folded peritoneum not obliterated by adhesions of its surfaces, is known as the cavity of the greater omentum. Its connection with the general cavity is at the right of the stomach in foramen of Winslow. This cavity varies in size; in childhood extending down into the fold of the omentum; or, owing to adhesive obliteration of the lower sac in adults, or absorption, this cavity often does not extend much below the lower margin of the stomach.[2, 6, 17]

The omentum possesses a remarkable vascular supply; its arteries coming from the gastro-epiploic, right and left; its veins empty into the portal vein. No nerves have been demonstrated; nevertheless, vasculomotor and trophic nerves must exist to innervate the different structures contained.

The lymph-stream is abundant and empties into the glands on the greater curvature of the stomach; in some cases fifteen or more may be seen. The majority are found between the greater curvature and the transverse colon, although some may extend below the lower border of the colon.[9, 16] The lymph-stream, after it passes the first chain of glands, empties into the retroduodenal, and from there into the receptaculum chyli.[14]

According to A. S. Warthin, hæmolymph glands of the splenic type are found, their position not being stated.[21] Melissinos, however, says that they are more numerous between the spleen and greater curvature of the stomach.

According to Robinson, many times in a hundred autopsies the omentum is entirely out of sight, rolled up above or under the transverse colon. In 10 per cent. of the cases it may cover the cæcum, and in 20 per cent. reach into the pelvis. It tends chiefly to the left and is found in 3 per cent. of all the herniæ.[18]

The position of the omentum in the abdomen is determined in part by the pumping action of respiration, intra-abdominal pressure, or more largely by the peristaltic movements of the intestines. By means of the latter, the omentum is kept unfolded, and is drawn to different parts of the abdomen with the movements of the intestines, so that each portion of the peritoneal cavity is touched at times by this membrane. The descensus of the same into the abdomen will depend not only on its length, but upon the position of the lower border of the stomach.

Histology.—The ground substance of the omentum is composed of connective tissue made up of a variable amount of fibers, white and elastic. The white fibers are arranged in a reticular manner, connecting with each other. The meshes of the reticulation are occupied by the ground substance of the membrane, bridged over by the flattened cells of the surfaces. These meshes may become open in many parts owing to absorption of the intervening ground substance and the perforation of the cells covering it.[17]

Klein says that in those animals in which the omentum is fenestrated in the adult condition it is not, or only imperfectly so, in the young condition, being then a continuous membrane composed of a layer of connective-tissue bundles. This fenestration is produced by cavities appearing between the connective tissue bundles, which cavities open through the interstitial cement substance of the surface endothelium. A direct transition of connective tissue corpuscles into endothelial cells of the surface is hereby established.[3] Lying upon these bundles of fibrous tissues are connective tissue nuclei or corpuscles. The corpuscles here and elsewhere belong to the fibrous tissue, and when separated from them, the bundles suffer in nutrition, and are extremely liable to die. Along with the bundles of fibers are intimately bound up arteries and veins; lymphatic vessels and lymph-canalicular spaces. The lymphatic vessels are composed of a thin endothelial wall; the lymph-canalicular spaces contain an albuminous fluid. The number of these lymph-vessels varies in different parts.[4]

The omentum is especially rich in groups of germinating cells; in many instances they are found on the surface of special thickenings of the normal membrane in connection with the vascular system. Sometimes they are found on peculiar papillary projections, particularly under pathological relations. The germinating endothelium sometimes contains cells which are in the act of division. Some are free and possess the power of amœboid movement, approaching the nature of the lymph-corpuscles. After becoming free, they find their way into the lymphatic vessels and then into the blood-vessels as colorless blood-corpuscles. In many mammals the amount of such germinating endothelium is very great, hence this membrane plays an important part in the generation of lymph and colorless blood-corpuscles.

The omentum also contains nodular or cord-like groups of adenoid tissue covered on one or more surfaces with germinating endothelium. These masses have either well-defined outlines or are more or less diffuse. According to Klein, the lymphatic tissue in the omentum, being possessed of a special system of blood-vessels, may at one time functionate as connective tissue, or at another time as fat-cell tissue.[8]

There is a large amount of adipose tissue which, towards the end of life, particularly in those people tending to obesity, accumulates considerable fat.

The surface of the omentum consists of a layer of endothelial plates (120 mm. in thickness) which are elastic; their interstitial cement substance being very soft. According to the state of contraction or expansion of the subjacent membrane or the direction to which it is being drawn, so will the shape of these plates be altered. There is a direct transition of connective tissue corpuscles into endothelial plates of the surface.[8]

Von Recklinghausen's claim that on the surface of the peritoneal cavity were stomata through which fluids freely passed to the lymphatic channels was so plausible, in consideration of the rapid absorption of fluids from the peritoneal cavity, that it went undisputed by histologists for a considerable time, until Muscatello and others disputed the presence of them.[11]

MacCallum, in a strong paper, controverts the statement that openings exist, and negatives the idea that the peritoneal cavity is part of the lymphatic system, and even further disputes that the endothelium has any connection with the adjacent connective tissue cells, claiming an independent development.[11] Sabion claims, according to embryological investigations, distinctive origins for the endothelial cells and the subjacent lymphatics.

Functions.—The several functions of this membrane are determined by the different tissues which go to make up its substance, and as this organ is insuperably connected with other tissues contiguous, much that pertains to the functioning of the omentum is associated with similar conditions existing in nearby structures. The study of one implies a knowledge of the action of all.

From the time of the early anatomists the sole function attributed to the omentum was that of protector of the intestines against chill. Like many fictions in medical literature this has long gone without protest. Of how little value it may be to the underlying intestines can be appreciated by any one who has taken the trouble to introduce a thermometer into a deep sinus and watched for the effect of an ice-bag on its reading.

I. Circulation.—The large blood-supply of the omentum makes it an important factor in maintaining an equilibrium of blood circulation. Physiologists teach the importance of the correlation between the intraperitoneal circulation and external conditions. Necessity demands, for relief of arterial tension, that some part of the circulation be capable of storing up blood. This the intra-abdominal vessels are alone capable of doing safely, being aided by the sensitiveness of the splanchnics to reflex irritation. Surgeons frequently note that during operations long prolonged the omentum changes color and becomes turgid with blood. Crile [23] holds that shock is due to reflex vasodilatation of the splanchnic area. The omentum with its loose tissues and numerous vessels must play an important part in this phenomenon. Under conditions which increase the pressure of blood in the portal system, the veins of the omentum become distended, and from them passes into the peritoneal cavity ascitic fluid. One observer, after amputation of the omentum for some incidental condition, noted the disappearance of the ascitic condition coexisting.

The omentum in its excursions through the abdomen may become adherent to some area of local inflammation and a collateral circulation sufficient to relieve the venous tension may be established.

II. Absorption.—Another important function is attained through the vascular system of the omentum in conjunction with the lymphatics; that is, the absorption of fluids and the taking up from the peritoneal cavity of suspended solids.

Wagner [22] estimates a dog's peritoneum as capable of absorbing in one hour an amount of fluid equal to ⅜ per cent. of the animal's body weight. Du Bar and Remy [22] found the thoracic duct of a rabbit greatly distended in five minutes after a large intraperitoneal injection of albuminous fluid: that the greater the percentage of albumin, the less rapid the absorption.

Absorption in the peritoneal cavity is partly by the lymph-stream and partly by the blood-stream. This absorption is not only of fluids, but of insolubles. Muscatello and Salzel claim that the solid particles are carried by the wandering cells to the lymph-stream, and the fluids largely by the blood.

Various factors influence the rapidity with which fluids are absorbed in the peritoneal cavity and the amount absorbed. Only under normal physiologic conditions can the maximum be obtained. The rapidity is regulated by two factors; the pressure exerted by the abdominal muscles and the movements of the diaphragm and intestines,—the diaphragm acting like a pressure and suction-pump. The movements of the intestines prevent the accumulation of fluid in any one part, so that it cannot follow the law of gravitation. They carry the fluids over the absorbing surfaces of the peritoneum and in this way greatly enhance the absorbing powers.

According to Nothnagel [14] the absorption of the intra-peritoneal fluid is directly proportionate to the activity of intestinal peristalsis. Reduction in temperature of the peritoneal cavity reduces the absorptive power of the omentum, due to diminished peristalsis; dilatation of the blood-vessels and increased peristalsis tending to promote absorption.

Dudgeon and Sargent in their book on "The Bacteriology of Peritonitis" [22] claim that whatever absorption cannot take place by the lymphatic channel must be done by means of the blood-stream. Provided that the endothelium is uninjured, bacteria and other foreign substances will be safely disposed of by the lymphatic route; but damage to the endothelium will at once allow absorption to take place by the vascular route, the extreme delicacy of the peritoneal membrane rendering it particularly susceptible to injury. The factors which retard or stop absorption have been investigated by Wagner and others, and are generally pathological. Venous engorgement may increase the peritoneal content. Reduction in the energy of intestinal peristalsis, together with diminished activity of the diaphragm, and loss of tension of the peritoneal muscles, retard absorption.

According to Byron Robinson,[18] the organ that the cells of the peritoneal cavity seek to become attached to is the omentum. Oppel [14] has suggested that the path taken by the lymph-stream from the peritoneal cavity is chiefly by the great omentum. He gives as his reason that in many cases where the peritoneal lymph was free from bacteria a deposit of microörganism was found on the great omentum.

Lodi [14] states that the omentum plays an extremely important part in the absorption of both microörganisms and solid particles in the peritoneal cavity. Durham found that in an animal killed twenty minutes after an intraperitoneal injection of bacteria, the omentum contained bacteria while the peritoneal cavity was sterile on culture.

Muscatello observed color particles taken up by the phagocytes, which rapidly passed between or through the endothelial cells into the subjacent lymph-spaces.

The nerve-supply of the omentum according to Marcy,[12] plays an important rôle in the organism, maintaining a suitable equilibrium of flows in the abdominal cavity.

III. Cohesive and Adhesive Properties.—The *co*hesive tendency of the omentum is first evidenced in fetal life, when the mesogastrium unites with the mesocolon through either degeneration and absorption of the endothelium or more likely a retrograde metamorphosis of endothelia into connective tissue corpuscles. This same tendency can be demonstrated in advanced life when conditions are suitable, and is often noted when the omentum becomes incarcerated in a hernia.

The *ad*hesive tendency of the omentum is a property peculiar to itself, as is the *co*hesive. When this membrane is irritated either through some regional inflammation or point of disturbed circulation, there is a transudation onto its surface, as well as into its superficial structures, of an exudate composed of white-blood cells and fibrin, which produce a stickiness. This leads the omentum to become attached to the offending portion and to encapsulate it. Continued irritation will lead to a marked hyperphasia of the omentum. If the source of irritation does not contain germs too pathogenic or too numerous, or if the phagocytes and the opsonic condition be satisfactory, the ultimate result will be a restitution and gradual absorption of the hyperplased and exuded material, and a return to normal. Not all of the endothelia being disturbed, new endothelia are formed. In the subendothelial tissue is maintained an excess of the fibroid which will materially interfere with subsequent absorption from that point. If the disturbance to the peritoneum be more or less general, there is, as we find clinically, an acquired immunity to secondary infections.

Experiments by Schlitzler and Ewald show drying of the peritoneal surfaces to be an important element in the genesis of peritoneal adhesions; at the same time it retards the rate of subsequent absorption of fluids.

IV. Protective Rôle.—The wonderful discovery by Metschnikoff of the phagocytic action of the white-blood cells receives no better illustration of its value in the economy than in the peritoneal cavity, as this tissue is greatly prone to invasion.

The slight amount of tissue separating the contents of the intestinal tract from the sensitive peritoneum, and the numerous organs subject to lesion and traumatism, render this cavity particularly susceptible to microbic invasion. Had Nature not a method of protection sufficient for ordinary disturbances, life would not be long lasting. In phagocytosis we have this means of protection and in the omentum a ready organ for its elaboration and action.

The phagocytes, drawn from the periphery by chemotaxis, associated with those formed from the transformed endothelia, the adenoid and connective tissue of the omentum, are extruded into the peritoneal cavity.

The peritoneal cavity normally contains a small amount of clear fluid in which are suspended a number of cells. The character of these cells, according to Kanthak and Hardy, is 30 per cent. to 50 per cent. polymorphonuclear.

Opie [24] states that polynuclear leucocytes with fine granulations accumulate in great quantity on the surface of the omentum and form compact clumps held together by a network of fibrin. The eosinophile leucocytes in large number penetrate into these masses of cells. He further claims that the eosinophile cells rarely if ever ingest bacteria.

Dudgeon and Sargent's experiments [22] seem to demonstrate that the granular eosinophile cells, which some have considered to be non-phagocytic and others slightly so, to be one of the most important, if not the most important, phagocyte in the early stages of peritoneal infection, while the finely granular polynuclear cells become a well-known important phagocyte in the later periods of peritonitis.

These same writers claim that on irritation of the peritoneal cavity, the staphylococcus albus appears on its surface, before there is any solution of continuity. It is generally found at a distance from the focus of irritation in association with numbers of phagocytes. Their conclusion is that from some unknown source this germ enters the peritoneal cavity ahead of all other more pathogenic germs, spreads rapidly over the entire peritoneum and omentum, and, by its minor irritation induces a rapid transudation of phagocytes, thus preparing the cavity to attack more virulent germs when they appear. Thus the omentum as a surgical factor in laparotomy is comprehended.

There is a general definite relation between the lymph-flow and cell-intrusion in the peritoneal spaces,—the obliteration of the lymph-channels from the peritoneal membrane by constriction of cicatricial tissue explaining why repeated lymphangitis becomes less and less dangerous.

Roger [10] considers the great omentum a flattened ganglia. To demonstrate the protective rôle of this membrane, he extirpated the omentum in rabbits and guinea-pigs. Later, after a period of a month or two, he injected into the abdominal cavity of the animals thus operated upon a few drops of the virulent culture of staphylococcus aureus. Death supervened in twenty-four hours, or at the latest within two or three days. Controls of the same weight to make the conditions identical having been subjected to a simple laparotomy, received the same amount of culture, but survived. It should not be concluded, however, that the extirpation of the omentum entirely destroys the resistance of the peritoneum, for the animals thus operated upon survive if they receive a very small dose of a virulent culture, or if an attenuated microbe be employed. In repeating the inoculation, however, he noticed that the animals deprived of the omentum grew thin and cachectic, and finally succumbed, while the control animal manifested no disturbance whatever. This rôle of the omentum is especially marked in the young, because with age a fatty infiltration occurs which diminishes the activity. It is, however, in children that the peritoneum is frequently threatened by microbes which swarm in the gastro-intestinal canal and so often cause inflammation there.

The plastic exudate thrown out by the omentum at the point of lesion doubtless offers some purely mechanical protection against the spread of infection; it may also be that the secretion poured out from the omental vessels has some antitoxic action. Further, the bacteria received into the lymphatics of the omentum are either rendered less virulent, or are else destroyed.

Byron Robinson says,[18] " the great omentum is a valuable peritoneal veil. It may present many cicatrices showing old peritonitis. It prevents the invasion of infection, and circumscribes inflammation. It is a great peritoneal protector, and the surgeon's friend, burying the mischief he has wrought. It may show by old inflammation that it has checked peritonitis."

Experiments by Schlitzler and Ewald[14] show a property of the omentum to be the rapid formation of plastic tissues on irritation, when an engorgement of the vessels takes place.

Robinson[18] claims that in nearly all experiments when congestion and peritonitis arose the most intense congestion appeared in the omentum, and thus in peritonitis in both man and animal this intense congestion of the omentum is a characteristic feature. He claims that the omentum in peritonitis attempts to corral the phagocytes, or their adherent microbes, by taking them out of the peritoneal fluid and making them adhere to its sticky surface. Careful examination will show that it harbors microbes while the peritoneal fluid is sterile on culture, but, if the microbes be very virulent, the stickiness of the surface will not suffice to ensnare or destroy them.

According to Warthin[21] after removal of the omentum. animals are more susceptible to intraperitoneal injections of microörganisms. In local traumatism, after operations and in local peritonitis, the omentum is commonly found attached to the affected area, shutting it off. The slightest irritation is sufficent to cause the omentum to attach itself.

V. Supplemental Function.—De Renzi[1] found that if the circulation of the spleen be entirely cut off, the omentum gradually envelops and forms a capsule around it, inside of which it is in time completely absorbed. If the omentum be removed after the circulation of the spleen be cut off, the organ does not become encapsulated, and the animal speedily dies. When toxins are generated by gangrenous degeneration of the spleen or other organs, the omentum seems to possess the power of neutralizing these toxins.

Pirrone[15] confirms the findings of De Renzi, and claims that the action is done by phagocytes originating in the omentum and devouring the detritus of the spleen. He compares the endothelium of the omentum to that of the blood-vessels in respect to thrombus. He claims that after extirpation of the spleen, there is nothing to indicate that the omentum undergoes modified transformation to compensate for the missing organ.

Pirrone proved the phagocytic action of the omentum. He experimented with injections of sodium taurocholate in splenectomized animals and induced immunization from this drug. When he compared the results with those obtained with nonsplenectomized animals, he found that the omentum had evidently tried to compensate for the absent spleen. Compensatory plastic processes in the lymphatic follicles were unmistakably apparent. The findings suggest functional relations between the spleen and the omentum beyond what physiologists have hitherto imagined.

Warthin[21] finds hæmolymph-glands of the splenic type existing in the omentum, and it is possible that they may take on vicarious action, become enlarged, and functionate for the destroyed spleen.

Résumé.—1. The numerous blood-vessels and lax tissues of the omentum allow of storage of blood when the general arterial tension is high.

2. By venous anastomosis through adhesions, local congestion may be relieved.

3. Through its large surface freely exposed to surrounding parts in motion, it becomes a rapid absorber of fluids by the blood-stream.

4. By the lymph-stream it is a free carrier of white-blood corpuscles, encapsulating solid particles.

5. Through its cohesive tendency, apertures in the abdomen into which the omentum has been forced by intra-abdominal pressure become more or less completely closed.

6. Through its readiness to lymph formation and local proliferation, it becomes attached to infected parts, which are walled off, subsequently to be absorbed by phagocytic action; the peritoneal cavity thereby protected.

7. The majority of the phagocytes extruded into the peritoneum for its protection come through the omentum, largely from the general circulation, but in part from the tissues therein existing; subsequently to be attached to the surface of this tissue, taken into the lymph-stream, and subjected to the cytolytic influences existing there.

8. Lack of development of the omentum, or loss through operation, renders one less resistant to peritoneal invasion.

9. Hæmolymph-glands of the splenic type existing in its base supplement the spleen if the latter be removed or its functions interfered with.

REFERENCES.

[1] De Renzi. In Journal of the American Medical Association, 1903.
[2] Gray. Anatomy, Descriptive and Surgical, 1887.
[3] Grieg-Smith. Abdominal Surgery, 1896.
[4] Hamilton. Text-book of Pathology, 1889.
[5] Heisler. Text-book of Embryology, 1899.

[6] Huntington. Anatomy of the Human Peritoneum and Abdomen, 1903.
[7] Jones. In Illustrated Medical News, London, 1888.
[8] Klein. Atlas of Histology, 1880.
[9] Leaf. Surgical Anatomy of the Lymphatic Glands, 1898.
[10] Lennander. In ANNALS OF SURGERY, 1902.
[11] McCallum. In Johns Hopkins Hospital Bulletin, May 1903.
[12] Marcy. In Journal of the American Medical Association, 1902.
[13] Melissinos. In Journal of the American Medical Association, 1901.
[14] Nothnagel's Encyclopedia of Practical Medicine—Diseases of the Intestines and Peritoneum, 1904.
[15] Pirrone. In Journal of the American Medical Association, 1903, 1905.
[16] Poirier and Cuneo. The Lymphatics, 1904.
[17] Quain. Elements of Anatomy, 1902.
[18] Robinson. In ANNALS OF SURGERY, 1899, 1900.
[19] Roger. Introduction to the Study of Medicine, 1901.
[20] Treves. In Allbutt's System of Medicine, 1901.
[21] Warthin. In Wood's Reference Handbook of the Medical Sciences, 1902.
[22] Dudgeon and Sargent. Bacteriology of Peritonitis, 1905.
[23] Crile. Blood Pressure in Surgery, 1903.
[24] Opie. In Transactions of the Association of American Physicians, 1904.